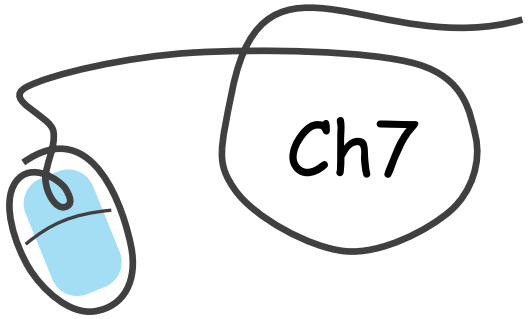

Digital Storage: Preserving Your Content

Dr. Jian-Ren Hou

Storage and Memory Uses

- Computers and devices use both **storage and memory** to access and save data and information.
- **Memory** consists of electronic components that store instructions waiting to be executed by the processor, data needed by those instructions, and the results of processing the data into information.

Figure 7-1 Storage is similar to a file cabinet for digital content.

Storage and Memory Uses

- **Storage** refers to long-term, permanent access to data and information.
- A storage medium is **nonvolatile.** Most memory (i.e., RAM), by contrast, holds data and instructions temporarily, thus it is **volatile**.
- A **storage medium**, also called **secondary storage,** is the location where a computer keeps data, information, programs, and applications.
- Examples of **storage media** include digital storage (cloud), and storage hardware, such as hard disks, solid-state drives (internal or external), memory cards, USB flash drives, optical discs, and tags.
- Cloud storage keeps information on servers on the Internet.
- In addition to programs and apps, users store a variety of data and information on storage media on their computers and mobile devices or on cloud storage.

Storage and Memory Uses

- A **storage device** is the hardware that records and/or retrieves items to and from storage media.
- **Writing** is the process of transferring data, instructions, and information from memory to a storage medium.
- **Reading** is the process of transferring these items from a storage medium into memory.

Figure 7-2 Various storage technologies.

Storage and Memory Uses

Capacity is the number of bytes (characters) a storage medium can hold. A gigabyte (**GB**) equals approximately 1 billion bytes. A terabyte (**TB**) is equal to approximately 1 trillion bytes.

Table 7-1 Terms used to define storage.

Storage Term	Approximate Number of Bytes	Exact Number of Bytes
Kilobyte (KB)	1 thousand	2^{10} or 1,024
Megabyte (MB)	1 million	2^{20} or 1,048,576
Gigabyte (GB)	1 billion	2^{30} or 1,073,741,824
Terabyte (TB)	1 trillion	2^{40} or 1,099,511,627,776
Petabyte (PB)	1 quadrillion	2^{50} or 1,125,899.,906,842,624
Exabyte (EB)	1 quintillion	2^{60} or 1,152,921,504,606,846,976
Zettabyte (ZB)	1 sextillion	2^{70} or 1,180,591,620,717,411,303,424
Yottabyte (YB)	1 septillion	2^{80} or 1,208,925,819,614,629,174,706,176

Storage and Memory Uses

- The speed of storage devices and memory is defined by access time.
- **Access time measures**
  - ✓ The amount of time it takes for a storage device to locate an item on a storage medium.
  - ✓ The time required to deliver an item from memory to the processor.
- **Transfer rate** is the speed with which data, instructions, and information transfer to and from a device.
- Transfer rates for storage are stated in KBps, MBps, and GBps.

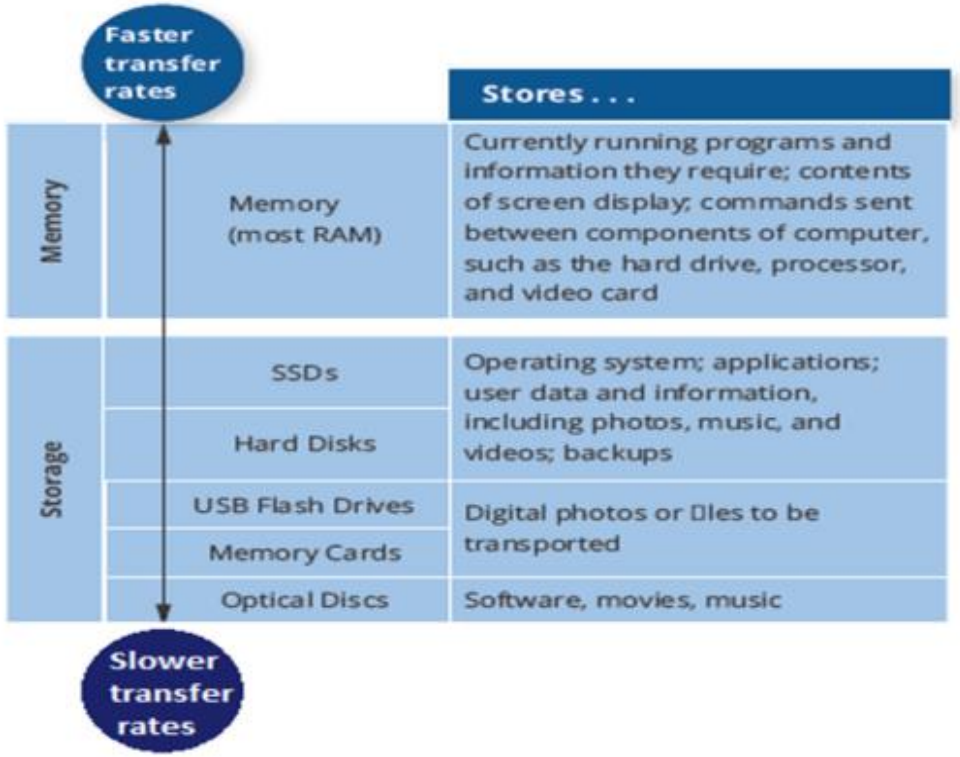

Figure 7-3 Relative speed and uses for storage media.

Storage Hardware

Hard Drives

- The most common storage medium is the **internal hard drive.**
- **Hard drives** can store data either magnetically or using solid-state storage.
- The files stored on the internal hard drive cannot be accessed on other devices.
- Magnetic hard disk drives (**HDDs**) have greater storage capacity and are less expensive than their solid-state equivalents.
- The term, “hard drive”, refers collectively to hard disks and SSDs.

Storage Hardware

- A **hard disk,** or **hard disk drive (HDD),** is a storage device that contains one or more inflexible, circular platters that use magnetic particles to store data, instructions, and information.
- Desktops and laptops contain at least one hard disk.
- The **storage capacity of hard disks** is determined by the number of platters that the hard disk contains, the composition of the magnetic coating on the platters, whether it uses longitudinal or perpendicular recording, and its density

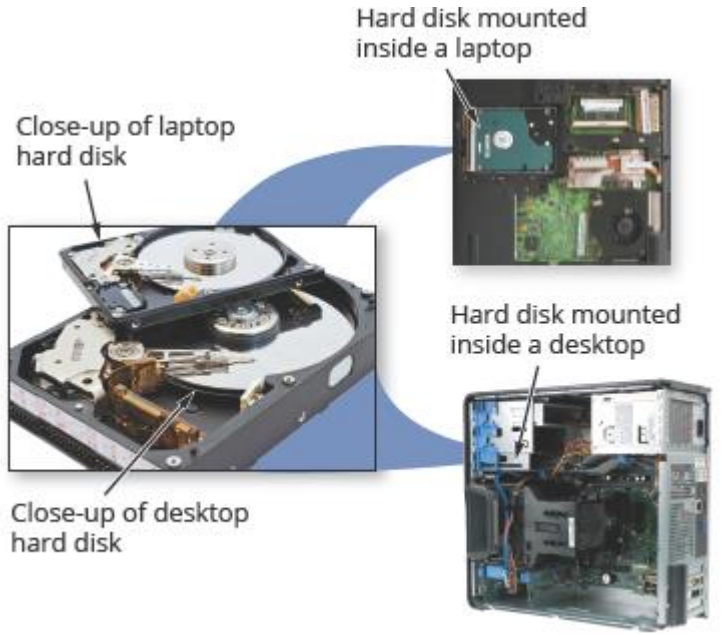

Figure 7-4 Typical hard disk.

Storage Hardware

- A **platter** is made of aluminum, glass, or ceramic and has a thin coating of alloy material that allows items to be recorded magnetically on its surface.
- **Density** is the number of bits in an area on a storage medium. A higher density means more storage capacity.

Storage Hardware

- A **track** is one of the series of concentric circles on one of the surfaces of a magnetic hard disk platter.
- **Tracks** are narrow recording bands that form a full circle on the surface of the disk.
- The disk's storage locations consist of wedge-shaped sections, which break the tracks into small arcs called **sectors.**
- A **sector** is an individual block of data or a segment of a track.
- Several sectors form a cluster.

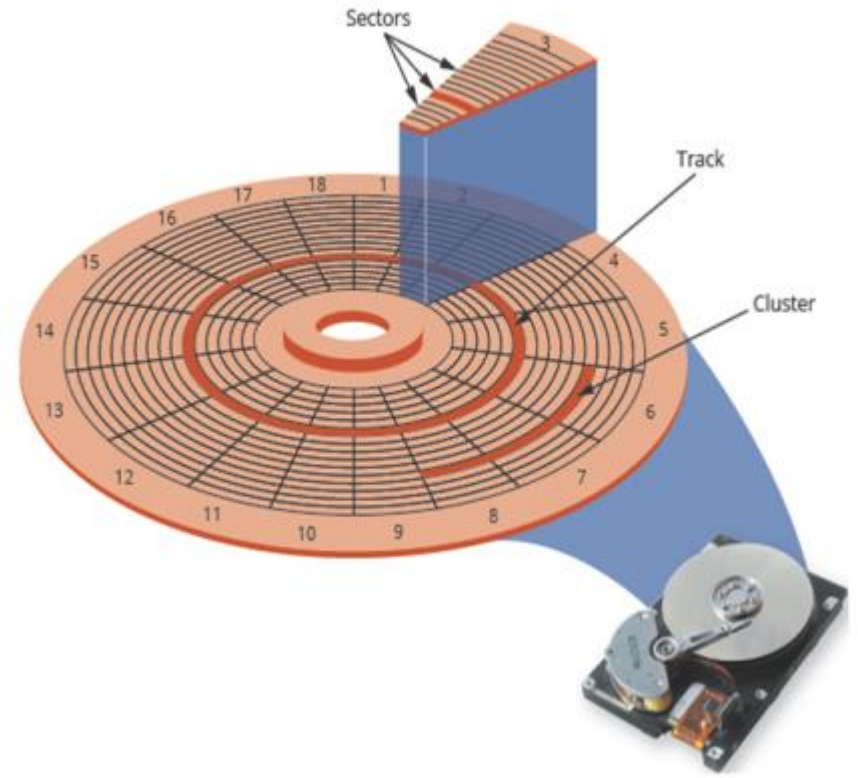

Figure 7-5 Tracks and sectors on a hard disk.

Storage Hardware

- While the computer is running, the **platters** in the hard disk rotate at a high rate of speed.
- This **spinning** allows nearly instant access to all tracks and sectors on the platters.
- The platters continue spinning or slow down after a specified time to save power.
- The **spinning motion** creates a cushion of air between the platter and its read/write head.
- This **cushion** ensures that the read/write head floats above the platter instead of making direct contact with the platter surface.

Tape Storage

- Using magnetic tape as a medium to store digital information. It's a type of archival storage that has been used for decades and is known for its high capacity and cost-effectiveness in long-term data retention.

Storage Hardware

- An **external hard drive** is a separate, free-standing storage device that connects with a cable to a USB port or other port on any device.
- Sizes and storage capacities of external hard drives vary.
- With an internal hard drive, an entire external hard drive is enclosed in an airtight, sealed case.

Figure 7-7 An external hard disk attached to a laptop.

Storage Hardware

- An SSD (solid-state drive) is a flash memory storage device.
- Flash memory is a type of nonvolatile memory that can be erased electronically and rewritten.
- Flash memory chips are a type of **solid-state media**, which means they consist entirely electronic components and contain no moving parts.

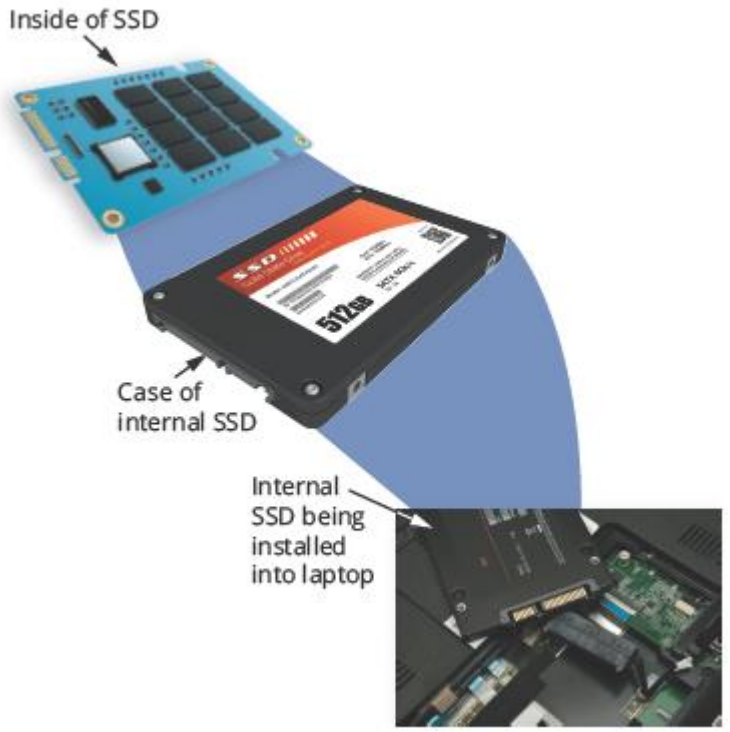

Figure 7-8 An SSD.

SSD (Solid-State Drive)

- Choosing an SSD: Key Criteria
  - PCI-E Gen4
  - Cell (SLC/MLC/TLC/QLC)
  - DRAM Cache
  - Heat (Heat Sink)
  - IPOS
  - Throughput
  - Latency

SSHD (Solid State Hybrid Drive)

- A type of hard disk drive (HDD) that combines traditional magnetic storage with a smaller amount of solid-state storage (SSD).

- The goal of an SSHD is to provide the high storage capacities of an HDD with some of the speed benefits of an SSD.

Storage Hardware

Portable Flash Memory Storage

- A **memory card** is a removable flash memory storage device.
- Memory cards enable mobile users to easily transport digital photos, music, videos, or other files to and from mobile devices and computers or other devices.
- A slot on a computer or device accepts multiple types of cards.

Figure 7-9 Memory cards often are used with cameras.

Storage Hardware

- A **USB flash drive (universal serial bus)** is a removable storage device for folders and files that plug in a USB port on a computer, making it easy to transport folders and files to other computers.
- The Storage capacities of USB flash drives and memory cards vary.

Figure 7-10 USB flash drive.

Storage Hardware

- **Optical media** include **CDs, DVDs, and Blu-ray discs** (BDs), but their use as storage media is declining.
- An **optical disc** is a type of storage medium that consists of a flat, round, portable disc made of metal, plastic, and lacquer that is written and read by a laser.

Table 7-2 Characteristics of optical disc formats.

Disc Type	Format(s)	Typically Use(s)
CD	• CD-ROM (read-only) • CD-R (recordable) • CD-RW (rewritable)	audio, photo
DVD	• DVD-ROM (read-only) • DVD-R, DVD+R (recordable) • DVD-RW, DVD+RW, and • DVD+RAM (rewritable)	video
Blu-ray	• Higher capacity disc than DVD	video

Cloud Storage

- Home and business users choose cloud computing for accessibility, cost saving, space saving, and scalability.
- Cloud computing consists of a **front end** and a **back end**, connected to each other through a network.
  - The **front end** includes the hardware and software with which a user interacts to access the cloud.
  - The **back end** consists of the servers and storage devices that manage and store the resources accessed by users.

Figure 7-11 Cloud storage.

Cloud Storage

- **Cloud computing** allows companies to outsource, or contract to third-party providers, elements of their information technology infrastructure.
- Cloud storage providers enable you to synchronize files, write documents, **backup files** on your computer or mobile device, share project work, stream music, post photos, and play games online.

Cloud Storage

- In addition to **SaaS** (software as a service), consumers and organizations rely on cloud computing services to manage:
  - ✓ Infrastructure as a service (**IaaS)**
  - ✓ Storage as service **(STaaS)**
  - ✓ Desktop as a service
  - ✓ Data as a service **(DaaS)**
  - ✓ Platform as a service **(PaaS)**
- Some additional cloud services include:
  - ✓ Synchronize files
  - ✓ Write documents
  - ✓ Backup files
  - ✓ Stream media

Cloud Storage

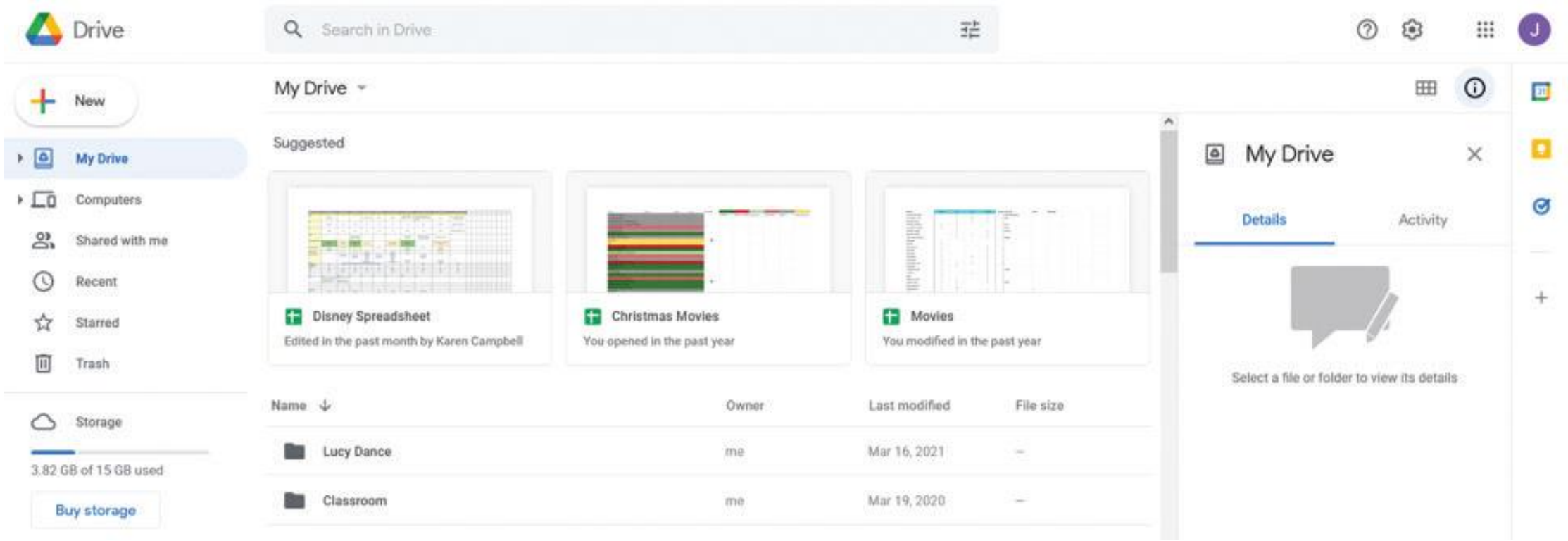

Figure 7-12 Google Drive.

Secure IT: Secure Your Data on the

- **Cryptocurrency** is digital currency that can be used to transfer money or payments between users or corporations.
- Cryptocurrency is not backed or secured by a government.
- **Payment apps,** such as Venmo, enable you to transfer money between your credit card or bank account and another user.
- A **digital wallet,** such as ApplePay, is an app that is connected to a specific payment card or financial account.

Figure 7-13 Using a digital wallet.

Enterprise and Other Storage Options

- **Enterprise hardware** allows large organizations to manage and store data and information using devices intended for heavy use, maximum efficiency, and maximum availability.
- Highly available hardware is accessible 24 hours a day, 365 days a year.
- To meet the needs, enterprise hardware includes levels of **redundancy,** which means that if one component fails or malfunctions, another can assume its tasks.
- Enterprise storage centers or a **data center** is a secure location with many large computers that act as servers, making files available to users.

Enterprise and Other Storage Options

- Some organizations manage an enterprise storage system in-house. Others elect to outsource all (or at least the backup) storage management to an outside organization or a cloud storage provider.
- A group of two or more integrated hard drives is called a **RAID** (redundant array of independent disks).
- **RAID** may duplicate data, instructions, and information to improve data reliability.

Figure 7-14 A data center.

Enterprise and Other Storage Options

- The simplest **RAID storage design** is Level 1, called **mirroring,** which writes data on two drives at the same time to duplicate the data. A Level 1 configuration enhances storage reliability.
- Other RAID levels use a technique called **striping,** which splits data, instructions, and information across multiple drives in the array.
- **Striping** improves drive access times.

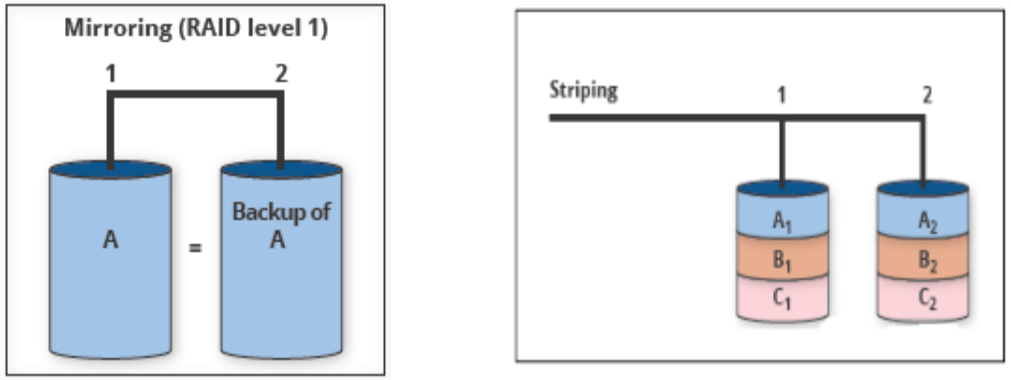

Figure 7-15 Mirroring (a) and striping (b).

Enterprise and Other Storage Options

- **Network attached storage (NAS)** is a server that is placed on a network with the sole purpose of providing storage to users, computers, and devices attached to the network.
- A **network attached storage** server, often called a storage appliance, has its own IP address, usually does not have a keyboard or display, and contains at least one hard drive, often configured in a **RAID**.
- **Administrators** can add storage to an existing network quickly by connecting a network-attached storage server to the network.

Enterprise and Other Storage Options

- **Other Types of Storage** include tape, magnetic stripe cards, smart cards, RFID tags, and NFC chips and tags.
- **Tape** is a magnetically coated ribbon of plastic that is capable of storing large amounts of data and information at a low cost.
- A **magnetic stripe card** is a credit card, entertainment card, bank card, or other similar card with a stripe that contains information identifying you and the card.
- A **smart card,** which is an alternative to a **magnetic stripe card**, stores data on an integrated circuit embedded in the card. Two types of smart cards, also called chip cards, are **contact** and **contactless**.

How Memory Relates to Storage

- **Memory** usually consists of one or more chips on the motherboard or some other circuit board on the computer.
- **Memory** stores three basic categories of items:
  - ✓ The **operating system** (a program that manages the complete operation of your computer) and other programs that control or maintain the computer and its devices.
  - ✓ **Applications** that carry out a specific task, such as word processing.
  - ✓ The **data** being processed by the applications and the resulting information.

How Memory Relates to Storage

- A **byte** is the basic storage unit in memory.
- When an application's instructions and data are transferred to memory from storage devices, the instructions and data exist as bytes.
- Each **byte** resides temporarily in a location in memory that has an address.
- An **address** is a unique number that identifies the location of a byte in memory.
- To access data or instructions in memory, the computer references the addresses that contain bytes of data.

Figure 7-18 Similar to seats in a stadium, one location memory (seat) holds a single byte (person) or can be empty.

How Memory Relates to Storage

- Memory capacity affects the device's operation speed.
- **RAM** is the most common type of **volatile** memory.
- Examples of **nonvolatile** memory include ROM, flash memory, and CMOS.
- **RAM,** also called **main memory,** consists of memory chips that can be read from and written to by the processor and other devices.
- RAM can accommodate multiple programs and applications simultaneously.
- Saving is the process of copying data, instructions, and information from RAM to a storage device or to the cloud.
- Today's computers improve their processing times with **cache (pronounced cash),** which is a **temporary storage** area.
- **Memory cache** helps speed up the processes of the computer because it stores frequently used instructions and data.

How Memory Relates to Storage

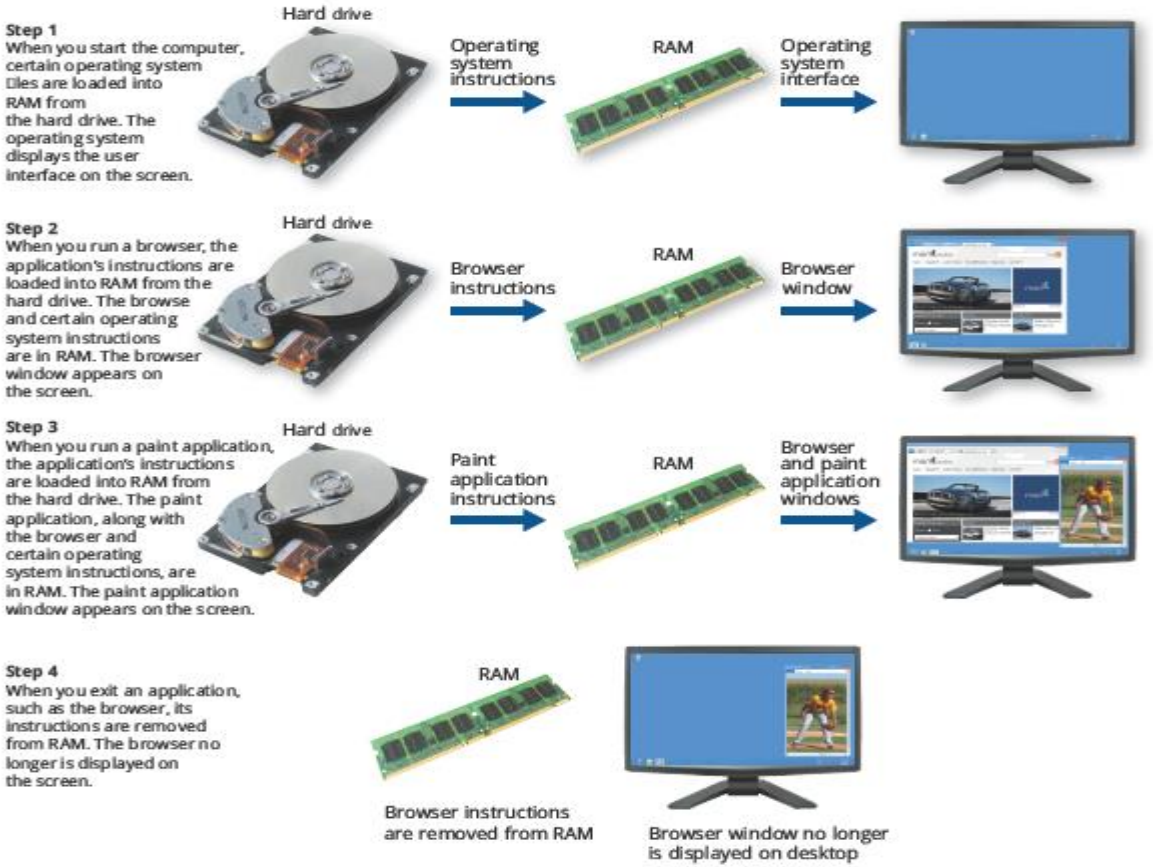

Figure 7-19 How program instructions transfer in and out of RAM.

How Memory Relates to Storage

- **ROM** (read-only memory) refers to memory chips storing permanent data and instructions.
- The data on most **ROM chips** cannot be modified so it is named as read only.
- Manufacturers of **ROM chips** often record data, instructions, or information on firmware chips when the chips are manufactured.
- These chips contain **permanently written data**, instructions, or information, such as a computer or mobile device's start-up instructions.

How Memory Relates to Storage

- Some RAM chips, flash memory chips, and other memory chips use **CMOS (complementary metal-oxide semiconductor)** technology as it provides high speeds and consumes little power.
- **CMOS technology** uses battery power to retain information even when the power to the computer is off.
- **Battery-backed CMOS** memory chips.
- The **flash memory chips** that store a computer's **startup** information often use CMOS technology.


Thank You